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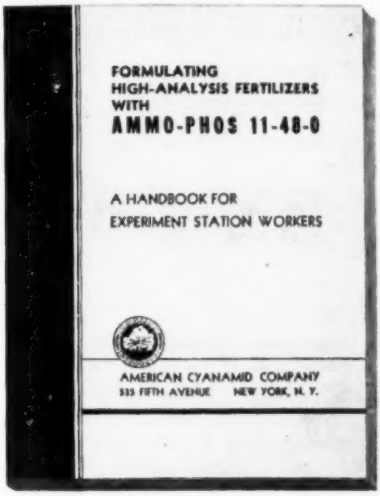

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American Potato Journal

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CHANGE IN POLICY

It has been deemed advisable by the Executive Committee to make certain changes in the policy of The Potato Association of America. For reasons of economy the separate volume known as the Proceedings of the Annual Meeting will not be published this year. The papers presented at the 1932 meeting in Atlantic City will be published in the Journal. It is hoped that the Journal will be considerably strengthened thereby.

Inasmuch as the membership in the Association was formerly divided into active and associate members, mainly on the basis that the active member received a copy of the Proceedings and the associate member did not, the dues for membership now will be at the same rate for all members, namely two dollars ($2.00) per year. Such dues will entitle the member to all rights and privileges in the Association and in addition he will receive the Journal.

It is the aim of the officers and of the Executive Committee of the Association to so shape the editorial policy of the Journal that it will appeal both to the scientific worker and to the better growers in the several states and provinces in North America. It is our hope that the grower will find enough in the Journal of direct benefit to him to amply repay the modest investment of two dollars. The experimentalist may find it to his advantage to foster this medium for the publication of his findings. As we are successful with these two groups the advertiser may well consider the Journal a profitable avenue of approach to his customers.

American Potato Journal

Volume X February, 1933 Number 2

BUD SELECTION[1]

J. R. LIVERMORE[2]

For many years it has been the custom of the president of our Association to discuss the needs of the Association, to tell us what is wrong with it and to suggest remedies for the situation in which we find ourselves. However, to keep in line with the theory of the new deal, so thoroughly established last November, I am departing from accepted custom. Today I have chosen to read to you a brief transcript of the cogitations of an arm-chair scientist on the perennially controversial question of the efficacy of bud selection in the asexually propagated plants in general and in the white potato in particular.

It has been said repeatedly, and much has been written to the same effect, that bud selection is of little use in the economic improvement of plants. In fact some have gone so far as to say that it is but a waste of time and money to pursue projects having to do with bud selection. A considerable quantity of data has been assembled to prove the point, but these very data are their own undoing in that for the most part they are derived from experiments so planned as to be wholly inadequate to prove or to disprove the effectiveness of bud selection.

In these earlier experiments the horticulturist would select one tree that had been producing high yields of fruit and another tree that habitually produced a low yield and then proceed to demonstrate the futility of bud selection. The usual procedure was to graft scions or buds from the 'high-yield' tree and the 'low-yield' tree onto root stocks and, after the wood had matured, relative yields were determined. In most instances little or no difference could be found between the two lines. As a matter of fact it would have been miraculous if there had been a significant difference between the two lines for it is but reasonable to assume that when selections are made in this manner the difference between 'high-yielding' and 'low-yielding' would be due primarily to environment.

Inherent ability to yield or the presence of heritable differences in yielding capacity of fruit trees will never be established by experiments founded on the selection of parent trees on the basis of their

[1] Published as Paper No. 192, Department of Plant Breeding, Cornell University, Ithaca, N. Y. Presidential address delivered at the 19th annual meeting of the Potato Association of America, in session at the Hotel Jefferson, Atlantic City, N. J., December 29 and 30, 1932.

[2] Research Assistant Professor of Plant Breeding.

annual production in one location. When hundreds of grafts of buds from each of many trees have been grown on uniform root stocks under comparable conditions to maturity, then, and not until then, may one begin to measure differences with such a degree of reliability that he may decide from an hereditary standpoint which is the 'high-yielding' tree and which the 'low-yielding' tree.

In order to adequately measure the difference in yielding capacity among the offspring of the selected trees it would be necessary to graft or bud uniform root stocks with hundreds of scions or buds from each of the two selected trees. If several crops of fruit from such an experimental orchard fail to show significant differences between the 'high' and the 'low' I shall be willing to admit that bud selection is of no avail in plant improvement.

In any line-selection experiment it would be entirely fortuitous if one should be able to establish significant differences between selected lines when the original selection was limited to so few individuals as two. The first selection should be from a large number of individuals because success in such an experiment is purely a matter of chance. The greater the number, therefore, the greater the chance of finding two plants that are inherently different rather than merely expressing the differences that exist in their environment. Many of the investigators have lost sight of this fact entirely as is evidenced by their use of a few trees or a relatively small number of plants.

How far would the cereal breeder have gone if his first selection had comprised but two plants instead of the thousands he used? How much progress would the corn breeder make if he recombined just two inbred strains or four in the case of a double cross? What chance has he to choose, among the hundreds of inbred strains, those two strains or those four strains that will make the best combination? These questions are answered by stating that it is utterly absurd to think of depending upon such methods to accomplish improvement in the cereals. Yet there are many who discredit bud selection, basing their judgment upon evidence resting on so precarious a foundation as the relative yield of two trees. Unless large numbers are available for the initial selection there is but little hope that much improvement will be accomplished by bud selection or any other form of line selection.

There are a few scientists who continue to believe that bud selection is an effective tool in plant improvement. These men conduct experiments to further refine the methods and to make practical application of the theory of clonal selection. Of course each and every selection project does not produce a new strain better than anything else on the market at that particular time. Why should it? Clonal selection in the potato is immediately handicapped by the nature of the crop. Potatoes are bulky to handle, to ship, and to store; potatoes are ex-

travagant in the use of land, the number of individual plants in a row is quite limited and it is impossible to test more than a very few strains in any one planting. All of these factors operate against the successful outcome of clonal selection. But even with this handicap the potato breeder has not fared too badly.

Consider for the moment the cereal breeding at Cornell. During the past 25 years literally thousands upon thousands of varieties, strains, line selections, and segregates from crosses have been tested and only about twenty strains of oats, wheat, and barley have been deemed worthy of distribution among the farmers of New York. It does seem a bit illogical to condemn clonal selection in the potato where hundreds, or less, instead of thousands have been used, or to discredit bud selection among the fruits where twos and threes have been utilized instead of hundreds.

For many years an extensive potato-breeding project has been maintained by the United States Department of Agriculture at Presque Isle, Maine. During this time one seedling has been named and distributed among the potato growers of the country. Thousands upon thousands of seedlings have been grown at Presque Isle—should we infer that genetic principles do not apply to the potato plant because only one strain of potatoes has been introduced? If the answer is no (as it should be) is there any more reason to say that bud selection in the potato has failed? None whatever. To my knowledge there has not been any test conducted that could prove or disprove the theory; no one has had the time, land, money, and facilities at his command to determine the efficacy of bud selection.

The method of improvement by bud selection never has had a chance to prove its worth. It may well be that it is impractical to use enough individuals in a given row or to use a sufficiently large number of replications of rows to reduce the experimental error to a level comparable to that of other crops. In the oat breeding plots at Ithaca, for example, each rod row is planted from 12.5 grams of seed and contains about 200 plants. Such a number of plants is large enough, considering the normal curve of error, to constitute a sample representative of any particular strain. Such a sample for potatoes would require one to two bushels of tubers and land enough for a row about 250 feet long. The facilities to conduct such an experiment with potatoes are not available at most of our research institutions. In other words, because of the necessity for small samples in potato research, experimental error is greatly increased.

In the small grains a five or six per cent increase in the yield of a selected line means something. For example, 53 bushels of oats is said to be better than 50 and using 10 replicates of single rod rows such a difference can be shown to be mathematically significant. But with the potato what does five per cent mean when based on a yield of 200 or

300 bushels per acre? Next to nothing. To measure such a difference in a carefully conducted test would necessitate the use of about 80 plots of each line being compared. Visualize a test of 100 strains of potatoes planted in 40-foot rows replicated 80 times; such a test would require about 20 acres of land and approximately 12 bushels of seed potatoes of each strain. In order to emphasize the difference in the actual handling of experiments with potatoes and with cereals calculation shows that to conduct a selection project with potatoes on a comparable scale with some line-selection projects recently inaugurated in China, where 2,000 to 5,000 selected strains are planted in rod rows replicated 10 times, would require from about 300 to 800 acres. If such a test could be conducted there is little question but that differences in inherent yielding ability could be demonstrated.

There are some who argue that selection within the potato is time wasted because it is not practical to measure so small a difference as five per cent. In other words, if one cannot measure small differences why bother at all. My reaction is directly opposite to that attitude. To me it is a challenge, an incentive to greater effort to devise ways and means such that it will be possible to measure small differences. Even though a five per cent difference cannot be measured there is yet much of merit in the tuber-unit selection method for it is possible to obtain a reasonably accurate estimate of 15 per cent or 20 per cent differences and that is worth while. The Mylico method of selection advocated and practised by the Department of Plant Breeding at Cornell involves not one year's test but three or four, thereby increasing the reliability of the estimates of relative yields to that extent.

Certain authors stress the fact that because of the difficulties involved in an adequate test the ordinary farmer cannot make use of clonal selection to improve his potatoes. Why should he? Do we expect the farmer to improve his wheat and oats and other crops by selection? No. Better strains of these crops are developed by breeding and selection by our publicly supported experiment stations—there is no reason why the improvement of the potato should not be handled in a similar manner.

It is difficult to conduct strain tests of potatoes and to accomplish improvement through clonal selection; the haphazard methods of so many of the experimenters in the early part of this century were wholly inadequate. A paragraph found on page 91 of the bulletin by Folsom, Owen, and Smith,[1] is well worth your attention:

"Whatever one's opinion may be regarding the causes of such differences as have been found in potatoes between commercial strains, and between tuber lines, it must be admitted that the problem of com-

[1] Folsom, Donald, Owen, F. V. and Smith, Hugh B. Comparison of apparently healthy strains and tuber lines of potatoes. Maine Agr. Exp. Sta. Bul. 358, July, 1931.

paring strains and lines is much more complicated than it was once thought to be. An adequate study of the problem in any region requires the knowledge and use of modern plot technique, of apparatus for controlling environmental factors, and of methods of diagnosing virus (or degeneration) diseases."

In one of the most thorough tests of the possibility of improvement in the potato by bud selection Myers (unpublished data) isolated from each of several stocks high-yielding and low-yielding strains that were materially different and it was possible to maintain that relative difference for nine years, at which time the project was terminated. Of course since this particular research was conducted from 1913 to 1921, many persons would say that the differences could be accounted for by the presence or absence of one or more of the virus diseases. Be that as it may, these strains were growing in adjacent plots year after year with ample opportunity for the dissemination of disease yet at no time were the plant pathologists able to identify any more diseased plants in the low-yielding strains than in the high-yielding strains.

It has been repeatedly stated that the greatest value to be derived from the tuber-unit selection process is the increased efficiency in the rogueing of diseased plants. The belief is quite generally held that practically the entire difference in yield of any two clonal lines of potatoes may be attributed to the varying amounts of disease in the two stocks. In the bulletin by Folsom, *et al.*, a random sample from two tables provide these data:

Averages for at least six rows (Table 1, p. 16)

Healthy hills %	Yield in bushels
81	432
98	450
74	443
80	455
99.8	440

Averages for at least four rows (Table 3, p. 24)

Healthy hills %	Yield in bushels
81	365
97	406
94	368
96	396
93	365
96	369
96	383

It is clearly evident that disease content alone cannot account for all the variation between these strains of Green Mountain potatoes when a plot 74 per cent healthy produces at the rate of 443 bushels per acre and the adjacent plot, 98 per cent healthy, produces at the rate

of 450 bushels per acre and another plot nearby, 99.8 per cent healthy, produces at the rate of 440 bushels per acre.

In the score or more of tuber-unit seed selection plots planted each year on the farms of growers of certified seed potatoes in New York it is not at all unusual to find diseased strains that outyield healthy ones. Often a row with 10 to 15 per cent of the hills rogued because of disease will yield more than a healthy row with a perfect stand of plants. If the experimental error incident to the conduct of all research is adequately discounted through the use of accepted methods of field plot technique then it is safe to assume that heritable factors are responsible, at least to some extent, for the observed differences in yield.

It has been my purpose to call to your attention the need of reweighing the evidence for and against bud selection; to emphasize the weaknesses of the earlier experiments and to point out some of the difficulties involved in the practise of clonal selection in the potato. Until such time as experiments planned and executed in the light of our present-day knowledge of the experimental-error concept have definitely proved the futility of clonal selection it would seem advisable to make the fullest use of this method of improvement as an aid in the development of better strains of seed potatoes.

THE POTATO SCAB-GNAT, *PNYXIA SCABIEI* HOP.

HARRY L. GUI
Assistant Entomologist, Ohio Agr. Exp. Station

The potato scab-gnat, *Pnyxia scabiei* Hopkins, in the adult stage is a small fly belonging to the family Mycetophylidae or fungus gnats. As the name of the family indicates, the larvae have the general habit of feeding upon fungi, but the larvae of this particular species, in addition to feeding upon fungi and decaying organic matter, may feed upon the flesh of the potato.

Adult males have well developed wings and are 1 mm. to 1½ mm. in length. The wingless females are somewhat larger, measuring from 1 mm. to 2 mm. Both sexes are dusky brown in color, which, together with their habit of hiding under particles of soil or in crevices, makes it difficult to observe them.

The eggs are white and measure .25 mm. in the greatest dimension. This small size makes them almost invisible to the naked eye. Eggs are most frequently found singly, although they may be deposited in clusters of as many as 20. Practically all eggs are placed in crevices or under loose particles on a tuber or in the soil. The incubation period averages 4.4 days, although as many as 8 days have been required in certain instances.

Newly hatched larvae have slender, transparent bodies with dark brown to black heads and measure 1 mm. in length. As growth progresses and the internal organs develop, the larvae become white and the head assumes a shiny, jet black color after the first molt. The length of the full grown larvae varies from 4 to 5 mm. This stage exists for an average of 11.4 days for the males and 14.1 days for the females, during which time the males molt three times and the females four times.

Pupation occurs within a delicate cocoon which the larvae spin around themselves immediately before pupation. The average length of time required for the pupal stage is between 4 and 4.5 days, being slightly longer for males than for females.

Mating takes place almost immediately upon emergence of the adults and egg deposition begins within a few hours. The maximum number of eggs known to have been deposited by a single female is 110.

A summary of life history studies indicates that an average of 22.6 days is required for the insect to complete its cycle. At this rate eight generations may occur in the field at Wooster, Ohio. At the maximum rate of development it is possible for 12 generations to develop.

Overwintering may take place in the storage or in the field.

It is safe to assume that the potato scab-gnat is distributed throughout the northeastern quarter of the United States. The present distribution records include the states of Delaware, Illinois, Michigan, Missouri, New York, Ohio, Pennsylvania, and West Virginia. The insect occurs in all parts of Ohio in sufficient numbers to cause economic losses each year and has been taken from certified seed shipped into Ohio from another state.

The potato scab-gnat is not dependent upon the potato crop for its subsistence. On the contrary it has been shown to be a rather general feeder. It is known to thrive upon the following plants and materials: Potatoes; peony bulbs; cucumber plants; parsnip roots; manure; leaf mold; decaying organic matter in the soil, such as straw, manure, buried bones; and damaged onion bulbs. On one occasion only has the insect been reported to be of economic importance to any crop besides potatoes. In this instance cucumber plants grown under glass in England were damaged.

Potatoes may be damaged in several ways. The damage which occurs in storage may be insignificant from the standpoint of direct losses. It has been demonstrated that the insect is capable of remaining active in cold storage having a mean temperature of 35.5° Fahrenheit with a fluctuation from 23° to 42°. The damage consists of enlargement of wounds infested at the time of placing the crop in storage and the infestation and consequent enlargement of injuries caused by other agencies.

Considerable importance is attached to the injury which occurs during the spring season. The damage results from the seed piece being infested by the larvae. The economic status of the insect during the spring season is dependent upon the severity of the infestation. It is not infrequent that seed pieces are infested only to a slight degree from which no direct losses are suffered. Injury of this sort is important, however, since it provides a source of insects which later may do considerable damage.

When the early spring infestation becomes intensified, actual losses may result. The cut side of the seed piece is usually attacked, although the skin side is often subject to injury. Whether or not losses occur depends upon the extent to which the flesh has been consumed. If no appreciable portion of the seed piece is destroyed, a thrifty sprout arises and becomes established. However, when a considerable portion has been destroyed, a weak sprout and a correspondingly reduced yield results. In extreme instances of this type of injury, the entire flesh may be destroyed, leaving nothing but the skin of the seed piece which is not capable of supporting a sprout until it becomes established. In certain fields the stand has been reduced 25 per cent by this type of injury.

Although the spring activities of the insect may, under favorable conditions, reduce the stand and the thriftiness of the plants, the activities which are carried on through the summer months are the most serious. These activities result in a tuber crop carrying wounds which vary greatly in number and size per tuber. According to surveys conducted in northern Ohio for 3 years, the potato scab-gnat maintains a position between the two groups of insects which have been considered the major subterranean potato pests; namely, the wireworms and the white grubs. Table 1 shows the results obtained from these surveys.

TABLE 1.—*Per Cent of Tubers Injured by Soil Insects in Northern Ohio*

Year	Wireworm	Potato Scab-gnat	White Grubs
1926	15%	6%	2%
1927	12%	3%	2%
1928	9.8%	4.5%	.45%

In some instances scab-gnat injury resembles common potato scab. There are differences, however, by which the wounds may be separated from scab lesions. According to pathologists, common scab lesions are surrounded by corky ridges arranged in concentric circles. The skin of the potato surrounding the wounds made by the potato scab-gnat is smooth to the edge. The insect may, and very frequently does, infest scab lesions. The corky ridges in such instances persist until the wound involves more area than was infected by scab. The wounds are

deeper than scab lesions and are more or less filled with a characteristic brown refuse. The larvae feed beneath this refuse on the healthy flesh of the tuber.

There are three types of tuber injuries which, however, are not separated by sharp lines of distinction: 1. Small, shallow, scab-like abrasions on the skin of the tuber. The number may vary from a single wound on a tuber to a great many, often involving the entire surface. 2. Large, shallow wounds. This is a common type in Ohio. Such wounds bear but little resemblance to scab. 3. Large, deep wounds. These may penetrate into the tuber to a depth of 1 inch.

Control investigation by plot work has been conducted for 3 years at Wooster, Ohio. Four factors have been found which have bearing on the control of the insect.

Treating seed with corrosive sublimate or hot formalin has been found effective in destroying the insects which have overwintered on seed potatoes. Should it be advisable for any reason to use infested seed, this may be safely done provided the seed is carefully treated. Seed treatment cannot, however, be relied upon to afford complete control of the potato scab-gnat because the insect may overwinter in the field as well as in stored potatoes.

In the experimental work thus far conducted it has been shown that damage is consistently higher on plots used continuously for potatoes than on plots on which crops are rotated. Several common farm crops may be used in the rotation, but the author has no special recommendation to make at this time since the problem is still under investigation.

Potato scab-gnat injury is more severe on sandy soils or on soils low in organic matter. This is borne out both by field observations and by plot tests.

In the plot work, comparisons of various treatments were made on Wooster silt loam. Certain plots in the experiment received no organic matter during the 3 years of the test; others received 10 to 20 tons of manure each spring before the ground was plowed; and on still others, potatoes were grown under a 3-inch straw mulch.

In the tests where organic matter was incorporated in the soil, 10 tons of manure per acre were used in 1927, whereas in 1928 and 1929 the rate was doubled.

In Table 2 is summarized the results of the three seasons' work. During the first year four plots of each treatment were used. The number was increased to eight for the last 2 years of the test. The data show clearly the value of a straw mulch and suggest a beneficial reduction in injury by making heavy applications of barnyard manure. Organic matter in the soil acts as a protection rather than a control, since the scab-gnat larvae prefer it to growing potato tubers.

TABLE 2.—*Relation of Soil Organic Matter to Tuber Injury by Scab-gnat*

	Treatment	Av. % injury	Treatment	Av. % injury	Av. diff. in % injury	Odds that results are not due to chance
1927	None	5.76	Straw mulch	2.84	2.92	20.1 to 1
1/80-acre plots	Manure	5.70	Straw mulch	2.84	2.86	11.4 to 1
	None	5.76	Manure	5.70	0.06	1 to 1
1928	None	5.60	Straw mulch	0.13	5.47	9999 to 1
1/129-acre plots	Manure	1.30	Straw mulch	0.13	1.17	63.9 to 1
	None	5.60	Manure	1.30	4.30	29.7 to 1
1929	None	6.33	Straw mulch	0.70	5.62	43.2 to 1
1/121-acre plots	Manure	4.49	Straw mulch	0.70	3.79	24.6 to 1
	None	6.33	Manure	4.49	1.84	2.6 to 1

A. D. Hopkins[1] found that the potato scab-gnat was tolerant to alkaline soil conditions. An attempt has been made by the author to utilize this factor in controlling the insect. Inoculated sulfur was applied to reduce the pH value of the soil, and ground limestone was used to increase it. Forty-eight plots were included in the experiment in 1927 and 1928 and 60 were used in 1929. A gradient of from pH 4.5 to pH 6.0 was obtained in 1927, 4.3 to 6.3 in 1928, and 4.6 to 7.8 in 1929. The percentage of tuber injury was determined at harvest time. When these percentages were plotted against the pH value of the various plots, a correlation was found to exist. While the correlation coefficients were low they were highly significant, excepting in 1927. Scab-gnat injury was practically eliminated when the reaction was as low as pH 5, although occasionally slight injury occurred at lower values. Table 3 summarizes the data obtained.

TABLE 3.—*Relation of Soil Reaction to Per cent of Potatoes Injured During the Years of 1927, 1928, and 1929*

Year	Range		Correlation coefficient	Odds that results are not due to chance
	pH value	% injury		
1927	4.5–6.0	1.1–10.1	.35	5.67 to 1
1928	4.3–6.9	0–11.9	.50	over 3,333,332 to 1
1929	4.6–7.8	0–21.1	.41	over 3,333,332 to 1

Under the conditions accompanying this experiment a considerable reduction in yield was obtained at the lower pH values. The practice

[1] Hopkins, A. D. Forms of so-called potato scab caused by insects. W. Va. Agr. Exp. Sta. Sp. Bull. 2, 97–111, 1895.

of reducing the pH value of the soil by the addition of sulfur has been tested under field conditions, to a limited extent, by growers in Ohio who report very favorably on the results obtained. The Department of Entomology has withheld a general recommendation for the use of sulfur until further field tests have been conducted. The reason for this is that the effect of such soil treatment upon the tuber crop must be established and suitable crop rotations must be devised before making such recommendations. The general utilization of sulfur on the soil to reduce the pH value will necessarily bring about a great change in the present methods of potato growing in Ohio, since it will probably eliminate the use of sweet clover so highly favored at the present time in the potato rotation. A great deal of attention is now being given to this phase of the work at the Ohio Agricultural Experiment Station.

SUMMARY

The potato scab-gnat causes a significant loss to potato growers in Ohio every year.

Eight to twelve generations may develop during the growing season at Wooster, Ohio. The insect may overwinter in storage or in the field.

Damage may be done to potatoes in storage, to planted seed pieces, and to the tuber crop.

Four factors have been found to have a bearing on the control of the insect:

1. Seed treatment.
2. Crop rotation.
3. The addition of organic matter to the soil.
4. Proper adjustment of the pH value of the soil.

THE RELATIVE RESPONSE OF POTATOES TO DIFFERENT FERTILIZER ELEMENTS[1]

T. E. ODLAND[2]

Considerable experimental work has been done at different experiment stations on the fertilizer requirements of potatoes. The recommendations have differed rather widely depending upon the soil type, geographical location, and variety of potatoes being grown. Generally, in the New England states, the crop has shown the greatest response to variations in the amount of potash used. In some instances, however, the response has been equally great to variations in the phosphorus content. In the South nitrogen is a relatively more important element in the potato fertilizer than in the more northern states.

[1] Published by permission of the Director of the Rhode Island Agricultural Experiment Station as Contribution No. 436.

[2] Agronomist.

At the Rhode Island Experiment Station potatoes have been used in various rotation and fertilizer experiments as one of the standard crops over a considerable period of years. In a number of these experiments the results obtained afford a good indication of the response of the potato crop to the different fertilizer ingredients. A summary of some of these results will be presented in this paper.

LEGUME VS. NON-LEGUME ROTATIONS

A series of crop rotation experiments were started in 1893. Among these were two 5-year rotations, E and F, which differed only in that legumes are included in rotation E but not in F. The rotation consisted of corn, potatoes, rye and hay 2 years. Recently this has been modified by substituting another year of hay in place of the rye crop. The same amount of commercial fertilizer is used for each rotation over the 5-year period. No stable manure is used in either rotation. Although the same amount of nitrogen is applied over the 5-year period to these two rotations, the amount used for the individual crops varies somewhat. More nitrogen is applied for the hay in rotation F than in rotation E and consequently less is applied to the other crops in the rotation. As a result the nitrogen applied for the potato crop averages about 20 per cent less on rotation F than on rotation E. The amount of phosphorus and potash has been the same for all crops each year in the rotation. The standard fertilizer used on rotation F has averaged about 1,500 pounds of a 4–9–8. A comparison of the yields of potatoes over the 39-year period is shown in the following table.

TABLE I.—*Yields of potatoes on rotations E and F. Total bushels per acre*

Year	E	F
Average 1894–1929	265	284
1930	340	409
1931	230	274
1932	284	392

The above figures show that over the 36-year period 1894–1929 the plats in rotation F produced an average of 19 bushels more per acre than those in rotation E. During the last 3 years 1930–1932 the differences in favor of rotation F have been much more decided. Not only has the extra nitrogen added in the fertilizer or supplied through the legume crop failed to increase the yield but has actually made conditions more unfavorable for potatoes. Evidently when potatoes are grown in a rotation where legumes are included regularly under these conditions the nitrogen should not be too high. Further evidence on this point will be presented later in this paper.

NITROGEN RESPONSE

Three levels of nitrogen are used on one set of plats as a check on the nitrogen requirements for the crops used in the rotations. The same rotation and crops are used on these plats as in rotation E. On one plat no nitrogen is applied in the fertilizer, on another approximately a 3–9–8 fertilizer has been used and on the high nitrogen, about 1,500 pounds per acre of a 6–9–8. No manure has been used. Potatoes are grown only once in each 5-year round of the rotation. The yields obtained are shown in table II.

TABLE II.—*Yield of potatoes on nitrogen experiment*

Year	No nitrogen	Medium nitrogen	High nitrogen
1909	203	232	289
1914	387	438	456
1919	245	338	325
1924	263	323	335
1929	252	333	235
Average	270	333	328

An average yield of 270 bushels has been obtained where no nitrogen was used, 333 bushels with a medium nitrogen and 328 bushels with the high nitrogen. In 1929 the high nitrogen plat yielded a third less than the medium nitrogen. Evidently in this rotation where a legume is included a 6 per cent nitrogen fertilizer has carried more nitrogen than the potato crop has needed.

PHOSPHORUS AND POTASH RESPONSE

Phosphorus and potash are varied on other plats where the same crops and rotations are used. The low potash fertilizer has consisted of about 1,500 pounds per acre of a 4–9–5 and the high potash of the same amount of a 4–9–10. For the phosphorus levels the same

TABLE III.—*Yields of potatoes on potash and phosphorus experiment*

Year	High potash	Low potash	High phosphorus	Low phosphorus
1914	464	440	465	435
1919	333	322	296	318
1924	316	276	337	306
1929	336	204	304	297
Average	362	310	350	339

amounts of 4–6–8 and a 4–12–8 have been used. Only 4 crops of potatoes have been grown on these plats. The results are presented in table III.

As may be seen from these figures the high potash plat has produced an average of 52 bushels more per acre than the low potash. The average difference between the high and low phosphorus plats has been only 11 bushels per acre. In 1929 the high potash plat produced a 50 per cent higher yield than the low potash. The crop on the low potash plat that year was very scabby while on the high potash plat they were practically scab-free. These results indicate the advisability of using a fertilizer with a relatively high potash content for potatoes under these conditions. The response of this crop to phosphorus has been relatively much less.

MAGNESIUM RESPONSE

On some plats where little or no lime has been used potatoes have shown a very characteristic magnesium deficiency. This has been especially true where liberal amounts of potash and nitrogen have been used in the fertilizer. Only two years results have been obtained so far but in both years very striking increases in yields of potatoes have been obtained under these conditions when small amounts of magnesium have been applied.

SOURCES OF FERTILIZER MATERIALS

In the experiments mentioned above nitrogen has been obtained usually from nitrate of soda and sulfate of ammonia, the phosphorus from superphosphate, and the potash from muriate of potash. In another set of experiments different sources of potash including kainit, muriate, sulfate, and sulfate of potash-magnesia are compared. All plats received the same amount of K_2O per acre with the exception of the low and the high potash plats. Through an

TABLE IV.—*Yields of potatoes with different potash sources*

Year	Potash sources					
	Kainit	Muriate	Low potash	Sulfate	Potash-magnesia	Extra potash
	Plat No. 114	115	116	117	118	119
1920	137	163	56	125	127	271
1922	166	124	47	106	134	179
1923	174	158	67	180	128	288
1926	170	194	72	202	193	348
1927	194	167	81	187	144	335
1930	323	383	236	393	302	461
1931	339	323	195	365	336	403
Average	215	216	108	223	195	326

error the sulfate of potash-magnesia plat also received a lesser amount over a period of several years. The yields obtained are shown in table IV.

Application 1930–31—1 ton 4–8–5, 4–8–2, and 4–8–10 for the regular, low and extra potash plats, respectively.

An examination of these figures shows that there has not been a very large difference in average yield between the various sources. The lowest yield where the standard amount of potash was used was obtained on the sulfate of potash-magnesia plat. This was undoubtedly due to the lower application over several years as explained above.

Where the potash was doubled the average yield was increased by 50 per cent. During the early years of the experiment no potash was applied on plat 116. However in later years a small amount as indicated has been used in order to get at least a partial crop.

In a similar test with different sources of phosphorus, yields have been about equal with superphosphate, basic slag, and triple superphosphate. Bone meal and rock phosphate have been less satisfactory.

SUMMARY

Results obtained in rotation and fertilizer experiments at the Rhode Island Station indicate that:

1. Potatoes can be grown satisfactorily in such rotations without the use of stable manure at any time during the course of the rotation.
2. A fertilizer too high in nitrogen should be avoided.
3. Variations in the amount of phosphorus does not influence the potato yields as much as variations in nitrogen or potash.
4. A fertilizer that is relatively high in potash is desirable.
5. Magnesium may become a limiting factor on these soils.
6. Different sources of potash have been about equally effective.
7. Rock phosphate and bone meal have not been as satisfactory sources of phosphorus as superphosphate or basic slag.

CROP AND MARKET NEWS

(Contribution from the Bureau of Agricultural Economics)

EARLY POTATO ACREAGE REDUCED

One of the hopeful signs of improvement in the potato situation is seen in the January report of intentions to plant. The commercial acreage of early and intermediate-crop potatoes, grown chiefly for shipping, is to be further reduced the coming season, according to January reports of 1933 planting intentions, received from growers

in areas throughout the southern States and north to Kansas, Missouri, Nebraska and New Jersey.

Indications are that the commercial plantings likely will be cut to 244,400 acres in 19 States. This would be a reduction of about 12% below their 1932 commercial acreage and nearly 30% below the 346,800 acres harvested in 1931. An increase of 11% over the 1932 acreage in lower Rio Grande Valley of Texas is more than offset by a decrease of 21% in Florida, making a net reduction of about 11% in those two districts, if growers carry out their plans as reported in January. In six other of the earliest States or areas, the intended commercial acreage for 1933 may be about 13% less than that harvested last year, Louisiana being the only State to approach very closely to the 1932 figure. A reduction of 24% is indicated for parts of Texas outside the lower Valley.

In the second-early group of four States, there appears to be a cut of only 2% from the acreage of 1932. North Carolina shows an intended increase of 6% over last season's figure, while Tennessee, Arkansas and Oklahoma report decreases, the greatest reduction in this group being for Oklahoma. Seven intermediate States or districts show an intended reduction of 13%. Kentucky growers alone are planning to maintain plantings at last year's total, all other intermediate shipping States reporting reductions ranging from 5% to 19%. Eastern Shore of Virginia may show a reduction of 23%, compared with the 1932 acreage in that district.

SECTIONAL NOTES

New York: Last year was one of the worst ever experienced by New York potato growers from the standpoint of market prices. Seldom is the value of the crop so far below cost of production that even the most efficient growers lose money in direct proportion to the volume produced. The good attendance and lively interest shown at the annual meetings of the Empire State Potato Club at Rochester on January 4 and 5, however, is proof that there is still enough of optimism among our growers to carry on.

The meetings, presided over by L. A. Toan, were attended by at least 300 growers and were full of latest information on marketing, grading, storage, pest control and cultural methods.

Roy Porter, of Elba, was toastmaster at the banquet attended by nearly 200. Joseph Hanley, of Perry, made the principal address and George Lamb, of Hubbardsville, made the presentation of medals and cups. The winners were: Paul Keel, Cassville; Morris Butts, Sodus; Shanley Bros., Paris; Oscar Alberding, Clayville; William Hutchings, Coldwater; W. G. Comstock, Clinton; Dennis Phelps,

Basom; I. C. H. Cook, South Byron; Floyd Wyman, Corfu; and Edw. Sparling, Akron. This year there were 37 contestants located in 5 counties.

A novel feature of the potato show, in charge of Charles H. Riley, was the fact that it occupied half of the main lobby and all of the balcony of Hotel Rochester. What better advertising could be given our product than to place it where the shopping and traveling public would see it at its best.

Frank Hobart, of Gabriels, won the sweepstakes' award, a silver loving cup, on a beautiful 32-tuber sample of Green Mountains. Much credit is due the American Agricultural Chemical Company for their generous contributions of cash and fertilizer premiums to winners in the 32-tuber exhibit. William Hutchings, of Coldwater, was the individual winner in the 100 pound field-run sample class. In the 4-H Club contest Madison County won first, Livingston County second, and Schoharie County third. Individual sweepstakes' winners in the 4-H exhibit were Derwin Alberding, of Oneida County, first; Arthur March, of Madison County, second, and Miss Fay B. Bachman, of Madison County, third.—E. V. HARDENBURG.

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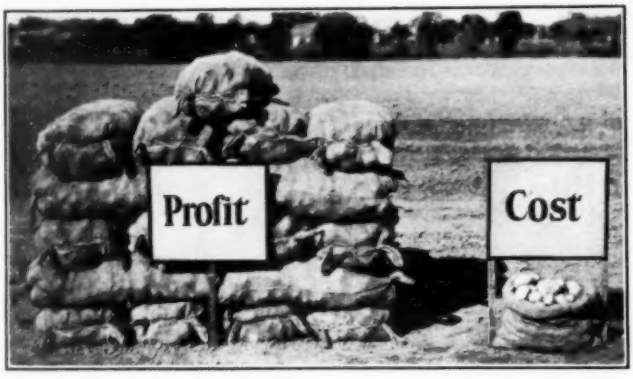

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